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ABSTRACT

An observational study examined computer writers' use of hard copy for reading. The study begins with a description, based on interviews, of four kinds of reading problems encountered by writers using word processing; formatting, proofreading, reorganizing, and critical reading ("getting a sense of the text"). Subjects, six freshmen enrolled in writing with computer classes and five more experienced writers for whom writing constitutes a major part of their work activities, were interviewed about their writing with word processing, were observed while writing in their natural environments, and kept process logs of the writing they were doing. Results indicated that: (1) individuals have difficulties reading their own writing on-line and they often supplement word processing with hard copy printouts for reading; (2) writers check formatting, proofreading, organization, and get a sense of the text from a hard copy; and (3) while there are differences in how student writers and more experienced writers use hard copy for reading, task variables such as length and difficulty may be important too. (Two tables of data and five figures are included; 19 references are attached.) (RS)

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"Seeing it on the Screen Isn't Really Seeing It": Reading Problems of Writers Using Word Processing

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"Seeing It on the Screen Isn't Really Seeing It": Reading Problems of Writers Using Word Processing

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> *The computer has completely changed the way I write...I rely on the machine completely....I couldn't go back to using paper... .*
>
> *I usually jot down a few notes and then begin typing....Then I get a printout to read through after the first draft...I get several printouts as I revise--to read and to mark with changes and notes....I always proofread on a hard copy... .*

These excerpts from an interview with Donna, a published technical writer and graduate student with several years' computer experience, are intriguing: Donna calls herself an "adamant computer writer" and believes she relies on the machine "completely." Like many writers who use word processors or computers, Donna likes the ease of making changes to her text, and she believes she makes more of them. She likes her computer's neatness, its speed, and--because she doesn't have to worry about typing or formatting concerns--she says she spends more time "really working on the piece."

Yet when prompted to describe how she typically writes on the machine, Donna does not tell a tale of complete reliance on the computer. Rather, while writing on the machine, she uses paper at almost every juncture in her writing process. Donna's interview is representative of many computer writers' responses: an

enthusiasm for the benefits of the computer as a writing tool, but also a continued reliance on paper. The writer's enthusiasm for the computer is clear. Also clear--to us if not to her--is that she doesn't rely "completely" on the machine, but supplements her computer use with pen and paper.

Donna's sentiments are echoed and her behavior is shared by many writers who use word processors or computers to write. Most of us who write using computers like the machine, but we also, to varying degrees, draw on the medium of pen and paper. It may not be surprising at first glance that writers use hard copy; after all, we all learned to write with pen and paper and few of us have computers available all the time. What *is* intriguing about computer writers' use of hard copy are the patterns that emerge--patterns both in the ways paper is used during writing and in the reported problems that the hard copy helps writers overcome.

The most common complaints of computer writers are difficulties they experience in reading their texts on-line. These problems can take a variety of forms. Some writers mention a difficulty in knowing how the finished product is going to look, while others have difficulty detecting errors on the screen. Writers seem to like the portability of paper--"I just have to take it away [from the workspace] to get a perspective on it."

Other on-line reading problems are less well defined. Writers also say they find it difficult to look at large sections of their writing on-line or move quickly to a specific place in the computer text. Others say they don't trust their own ability to read critically from the screen, reporting a problem "getting a sense" of their on-line texts. In any case, most of the computer writers I have interviewed do what Donna reported doing when faced with these reading problems: they print out their texts and read from hard copy. One writer put it this way: "I use hard

copy because seeing it on the screen isn't really seeing it."

Determining why writers who use computers often rely heavily on paper and how they use the hard copy can inform our theories of the relationship between reading and writing, telling us more about how writers read their own texts. In addition, studying writers' use of hard copy can furnish important information to teachers and other educators about how computers can be put to best use for writers. This paper begins with a thorough description, based on interviews, of four kinds of reading problems encountered by writers using word processing. Following this description, an observational study of computer writers use of hard copy for reading is described and results presented.

Reading on the Screen: Research in Human Factors

That computers cause problems for readers is not news: several researchers have suggested that reading on a computer screen may be problematic. Taking tests on computers is slower than taking the same tests on paper, according to Hansen, Doring, and Whitlock (1978), who explained their results as a function of slower on-line reading time. Gould and Grischowsky (1984) conducted a study in which 22 of 24 subjects read more slowly from a CRT display than from paper. In a series of follow-up studies, Gould and his colleagues (1987) systematically explored variables which may explain the results of the 1984 study, including reading angle, resolution, font size, and experience. Through ten follow-up studies, the finding of slower CRT reading remained consistent and robust. Gould explains the results:

> No one variable studies (e.g., experience in using CRT displays; display orientation; character size, font, or polarity) explains why this reading speed difference occurs. We tentatively conclude that the difference is due to a combination of variables. These could possibly interact in non-linear ways, together exerting an effect greater than their individual contributions.

Not only is reading on a computer screen slower, but it may be less accurate. Wright and Lickorish (1983) found subjects' proofreading on hard copy to be more accurate than that on computer screens, and Heppner, Anderson, Farstrup, and Weiderman (1985) discovered Nelson-Denny reading performance scores to be significantly better with paper than with computer. In addition, Heppner et al.'s subjects reported "strong subjective beliefs that they could read the printed material faster and that it was easier to comprehend." John R. Hayes and I examined subjects' performance in writing-related-reading tasks in a series of three comparison studies (1986). We found that students were less accurate in recalling spatial location of items (i.e., describing where in a text a particular piece of information occurred) when they read from a screen than when they read from paper. A second study compared students' retrieval of information from a standard green-on-black CRT display, from a bit-mapped, high resolution black-on-white display, and from paper. Scores for the CRT condition were significantly slower. Results from a third study showed that reading-to-reorganize was significantly slower on a small screen display than on paper or on a large screen display.

Several researchers on writing have mentioned the unwillingness of writers to do without hard copy. Researchers have pointed out that both experienced writers (Bridwell, Nancarrow, & Ross, 1985) and student writers (Harris, 1985) report a continued and extensive use of pen and paper. Given the constraints on reading outlined above, we might predict that computer writers frequently use paper for reading.

Reading One's Writing On-Line: Four Areas of Impact

A series of on-going interviews with 22 computer writers has given me

information about how writers view word processing, the changes in their writing that they perceive, and--the focus of this discussion--the problems they have encountered with word processing. The writers who were interviewed exhibited wide range in age and computer experience, from a beginning graduate student who used word processing mainly as a "fast typewriter" to a computer scientist with 18 years experience with computers. Some of the writers were interviewed once; others met with me several times and allowed me to examine some of their texts. One subject--a novelist--shared his experiences learning to use word processing after over 30 years composing at a typewriter. Interviews with this writer were conducted periodically over the course of several months. An earlier description and analysis of some of these interviews is presented in Haas and Hayes (1986).

The hardware and software used by the writers also varied. Some writers used mainframe, time-sharing computers and terminals and the text-editor EMACS (Stallman, 1981); others used personal computers, like the Apple Macintosh or the IBM-PC, running software packages such as *Wordstar*. A number of the writers used an advanced system under development at Carnegie Mellon, the Andrew system, which runs primarily on an IBM PC-RT (Morris, Satyarayanan, Conner, Howard, Rosenthal, & Smith, 1986). A few of the writers were facile with more than one system. In spite of these machine differences, the uses to which writers put hard copy were remarkably consistent across writers and--predictably--hard copy was often used for reading during writing. I postulate that writers used hard copy for reading because, as is suggested above, reading on a computer can be problematic in a variety of ways.

The interaction of reading and writing is complex. There are several ways in which reading is crucial in the writing process, and there were in fact several

distinct reading problems for computer writers. In the following sections I outline four areas of impact--areas in which the computer seemed to influence writing negatively by causing reading difficulties for the writers I interviewed. These problems seemed to be caused by different computer features, and they were overcome--with computer or with paper--to varying degrees and in various ways. The four impact areas are: formatting, proofreading, reorganizing, and critical reading or "getting a sense of the text."

Formatting

Since many texts that writers produce are intended to reach readers on paper, it is not surprising that writers were concerned with final hard copy format. Formatting concerns took a variety of forms. One writer used paper printouts because he knew readers would read it from paper--"I like to see it the way they will see it." Sometimes writers needed to check the finished text for page breaks or placement of figures and tables.

The source of this problem for writers is fairly easy to identify. Very few editors are "WYSIWYG" or "what-you-see-is-what-you-get" editors. The differences between what is on the screen and what will be on the printed page can differ from machine to machine and may include different font size and type, differences in leading and resolution, no page breaks, differences in line-length, no integrated graphics, and abbreviated margins. Some advanced systems (e.g., the Andrew system under development at Carnegie Mellon) have a special program which writers can run to see a "picture" of their finished texts. However, many computer writers must generate a printout in order to see the finished format of their computer text.

The hard copy solution to the concern for formatting is fairly straightforward, if

time--and paper--consuming. Writers seemed to make a best-guess on-line approximation of the formatting they wanted, then generated a hard copy to skim, looking for specific problems. If necessary, they may have gone back into the editor to make changes. Writers often cycled through several iterations of this process.

Proofreading

A second area in which computers affected writers negatively was during close reading or proofreading. Many computer writers reported not "trusting" their ability to proofread on the screen, and they often used hard copy to read for local errors. Interestingly, several writers noted that computer-based spelling and grammar checkers tend to compound the problem: writers learned to depend on the computer tools for low-level problem detection and so they either did not proofread at all, or they did it haphazardly. This problem was exacerbated by the fact that many problems are not detected by computer-based tools for instance, missing pluralization or the mistyping of one word for another, for example, "test" for "text."

While computers may greatly facilitate a writer's ability to *make* low-level changes, the skill and speed with which writers *detect* the need for changes may be decreased when using a computer screen. Gould and Grischowsky (1984), Gould et al. (1987), and Wright and Lickorish (1983) have concluded that readers are slower and less accurate when proofreading on-line. Given these robust findings (discussed above), writers who proofread their texts on hard copy printouts are apparently doing the right thing.

Reorganizing

A third way in which computer writers used hard copy was in planning and

testing large text reorganization moves. While word- and sentence-level revisions and reorganizations are easy on a computer, writers reported that computers constrain large text reorganizations--involving a move of several paragraphs of text, or a move over a large amount of text space. As one writer put it, "That's when you just have to get your pen and spread the thing [the text] out all over the floor." In a previous experimental study, we found that students reading to detect needed reorganizations worked more slowly on a PC screen than they did on a larger screen or on paper (Haas & Hayes, 1986). Many writers also made extensive use of graphical markings during reorganization--arrows, stars, or brackets that were quick and easy to make on paper but difficult to make on-line.

Reorganizations were difficult on the computer in two distinct ways:

(1) **Planning** the reorganization move, or deciding what needs to be moved where, is difficult because one generally has only one view (screen) on the document at once, although split screen options or multiple windows of text may alleviate this problem. Planning a reorganization is also difficult because writers often "get lost" in computer texts, which provide many fewer cues for spatial recall than do paper texts.

(2) **Testing** the reorganization move is problematic because one has to make the move to test it; i.e., in order to see how the text would read with a large text reorganization, one has to actually reorder the text. With paper, on the other hand, a writer can place the sections in question next to one another by reshuffling pages, or he/she can quickly flip through the text, reading and "trying out" the reorganization move. In addition, because the word processor may neatly reformat the text once a major change is made, it is often hard to remember exactly how the change was accomplished.

An extended example illustrates these difficulties. While Donna is producing an article (or other lengthy document), she realizes that her introduction is too long and either needs to be cut, or parts of it should be moved. If Donna were in fact "completely reliant" on the computer, her reorganization might proceed like this: she might read through the introduction and then try to "keep it in mind" as she skimmed the rest of the document to see if part of the introduction could be used elsewhere. Or, if she had an advanced editor, she might use a split-screen option and have two views of the document: a window with the introduction and a window where she read the rest of the text. Of course, the whole introduction may not fit in a window so she would need to scroll or key forward and back in both windows, and, since there are limited page and other spatial location markers (e.g., the top right corner of page five, or the middle of page twelve), she could easily become "lost," or confused about which part of the text she is viewing and where it is in relation to the rest of the document.

After reading through the text, Donna decides she wants to try moving three paragraphs of the introduction into the discussion of a major point about half-way through the text. Using the computer alone, she might "cut" the three paragraphs, then scroll through the document until she finds the place where it should be inserted. Once she "pastes" the text in, she reads the section to test her new reorganization. Given the limited space on the screen, and the difficulty in quickly skimming through the text, the reorganization cannot be tested until it is actually executed. If Donna decides that she does not in fact want her text reorganized in this way, she must "cut" the text again and move back to insert it in the original spot, which she may or may not have remembered to mark with an asterisk.

But since Donna is an experienced and smart computer writer, in actuality she

would probably get a printout of the text and plan and test her reorganization on the hard copy. She could pull out the page, or pages, that contain the introduction and lay them out in front of her and then read through the paper--referring frequently to the introductory pages spread out before her. The interval between looking at the body of the article and the introduction is very short--it involves just a flick of the eye--and the space available to spread the text out is as big as her desk, or the floor of her living room. Once she identifies a potential reorganization, she can bracket the three paragraphs she wants to move (also using the spatial cue that the paragraphs are on the bottom of page two and the top of three), turn to page eleven where she plans to insert them, place the two parts together and read through to "test" the reorganization. If she doesn't like it, she just doesn't execute the move. Only after planning and testing several reorganizations in this way, does Donna move back to her computer to reorder her text on-line.

Most of the experienced computer writers that I have interviewed and observed reorganize their texts the way Donna did--by using hard copy. There are, however, software features that could help in planning and testing these large reorganizations. Large screens, which make more text available at once, can be helpful (Haas and Hayes, 1986), as can "search" features which allow writers to quickly move to other places in their texts. However, it may be an inherent shortcoming in the computer as a writing tool that **planning** a text change is difficult without **executing** that change. Further, since many computers reformat completely after text changes, undoing a revision and recovering the original may be difficult. Some programs support an "undo" feature, but it is usually limited to the last command the writer issued. With some word processing systems, writers can exit without saving changes, then call up the file again to retrieve the original, unchanged text. However, this is

not possible if the text has been "saved" since the changes were made and in any case may be time-consuming or require a high level of expertise.

The speed and efficiency with which the computer reformats after changes was a problem in other ways too: one student writer told me "I like to make my changes on hard copy so that I can see they're really changes--then I feel like I'm really accomplishing something." And a published novelist spoke of the fact that with his computer he felt a loss of the "history of the text--those lines you discard and then want to pull back later--with the computer they're just gone."

Critical reading and the "text-sense problem"

A fourth area of negative impact of the computer occurred during critical reading or assessment. Successful writing requires self-assessment, or reading to evaluate. Hayes, Flower, Shriver, Stratman, and Carey (1986) describe three phases of revision: detection of the problem through reading, diagnosis or determining its nature, and adopting strategies to solve the problem. While local revision may involve reading to detect a mismatch between the written text and conventional rules or maxims, whole text revision often requires reading for and detecting a mismatch between the written text and the author's intentions or the audience's needs.

Using a computer to write seemed to constrain writers' ability to read and assess how well the text met their own intentions, what Witte (1985) calls matching of the projected text, or "pre-text," to the written text. Writers that I interviewed mentioned this problem with amazing regularity, and often used the words "sense of the text" when describing this problem--"With the computer I have no sense of the whole text." Some writers used metaphors to describe the problem: "My text is hard to pin down on-line"; "There is a problem getting a

feel for the piece"; "It's hard to get your center of gravity in the writing."

"Getting a sense of the text" is the kind of self-critical reading that is crucial for successful writing and revising. Reading for a sense of text includes testing the text by matching it to the writer's goals to determine *if* text reorganization or other revisions are needed. In addition, when reading for a sense of text, writers try to "construct" the text as a reader would, thereby noting problems that readers might have with the text.

We can learn more about the text-sense problem by placing it in context and asking:

1) When in the writing process(es) does it occur? and

2) With what types of writing does it occur?

First, the text-sense problem seemed to be localized, as was suggested earlier, during assessing and reviewing junctures in the writing process: when moving from one text section to another, when moving from first draft to initial assessment and revision, or prior to a final reading and review. The text-sense problem seems to occur in this way: writers produce some amount of text, stop to check progress, assess results, or match text to goals, and discover that they cannot adequately assess the text when it is on-line. So writers generate hard copy, read the printout, make changes (on-line or on paper), or--satisfied that the text is all right--resume computer writing. Although writers may interrupt themselves to print hard copy, then wait for several minutes (or hours) for the printout, they often do little more than read it. In fact, the text-sense problem seems to be a complex constructive reading problem, a problem reading to construct, or reconstruct, the macro-structure of meaning in one's own text.

When writers speak of the text-sense problem, they may be describing a difficulty in representing their text--its meaning and structure--to themselves. To detect a mismatch between intended text and actual text, a writer must have a representation not only of his or her own intended or "projected" text, but also a representation of the actual text. If reading to "get a sense of text" is important for representing a text to oneself, it is much more closely tied to the compositional or "meaning making" aspect of writing than are proofreading or checking format and so may be a potentially more important problem for computer writers.

Second, the text-sense problem does not seem to be constant across writing tasks. It seems to occur most frequently and acutely in tasks such as those Bereiter and Scardamalia (1982) have labelled "compositional tasks": tasks in which the structure of information in the writer's memory does not easily map onto the finished text and tasks that require the forging of new connections and links in the writer's knowledge. For instance, one writer told me, " It was easy to do my [doctoral] exams on the computer because I really knew that stuff and I had a good idea from [my advisor] what the questions would be." However, in texts where writers are forming and developing new ideas, getting a sense of the text--i.e., adequately representing the text to oneself--may be more difficult. If the text-sense problem is a problem in representing one's text to oneself, it is not surprising that it is more acute in cognitively difficult writing tasks where the structure of knowledge, newly formed, exists tenuously in the writer's memory. In this situation, the external memory furnished by the written text is particularly important.

In addition, the text-sense problem occurs most frequently with long writing tasks, rarely occurring when the writer is producing a product that is just one or

two screens long. This too makes sense from a cognitive point of view: the size of the text makes it difficult to hold an adequate representation in memory. The length and difficulty of the writing task may interact as well, making "getting a sense of the text" difficult. For instance, one writer said that writing letters of recommendation for students, a task he does frequently, was easy to do on-line without hard copy. However, he found that writing a letter of application for a summer scholars' program--a task of about the same length but one which was much less well-rehearsed and possibly more important to him--was impossible to do without frequent hard copy reading and editing.

Writers also spoke in interesting ways about their relation to their own on-line texts. For instance, writers reported that they needed to read their texts from hard copy to "get some objectivity." This may be related to the display problems which contribute to proofreading and other reading problems (for instance, poor resolution makes reading for fine features like letters difficult) but it may also be due to the fact that the computer is stationary: one can't take it on a walk, or even into the next room. Many of the writers I spoke with mentioned their need to get away from their workspace--whether writing with computer or with pen and paper--to establish some distance or objectivity with their writing.

Paradoxically, other writers complained that they felt *too much* distance from their computer texts: "I just don't feel that I know my text as well when it's on the screen." They used words like "immediacy" and "intimacy" as qualities that were missing when they read their own texts on a computer screen.

Further, using word processing may constrain a writer's spatial sense of his or her own text. In an earlier study (reported in Haas & Hayes, 1986) it was discovered that readers' abilities to recall spatial location within texts was

constrained by the machine. We are familiar with the phenomenon of spatial recall (Rothkopf, 1971): in reading a novel, we may not remember the maid's name, but we can remember that she was introduced in a lower paragraph, on the right hand side, about one-third of the way through the book.

Spatial location is not constant on a computer screen; it is not controlled horizontally on most machines, and computers with variable width windows do not even have constant vertical markers. Writers seem to use cues like top and bottom of page, or left and right side, to mentally mark important points or specific parts of their writing. Recent work regarding how people learn from texts has pointed to the importance of "spatial learning strategies" in understanding and remembering texts (e.g., Holley & Dansereau, 1984). Kotovsky, Hayes, and Simon (1985) hypothesize that one factor contributing to differences in difficulty of isomorphs of the same problem is increased spatial memory load in some of the versions of the problem. Certainly the fact that scrolling text does not have a constant physical configuration may contribute to computer writers' problems representing in their texts to themselves and suggests that physical and spatial aspects of the text may provide cues to writers, helping them represent structure, meaning, and intent.

Ironically, some of the real strengths of the computer as a writing tool--its speed and capacity to reformat after changes--may in fact contribute to the text-sense problem. Because, for many writers, text production is faster on-line and because there is no need to recopy after changes, writers may not spend as much time producing and reproducing their texts. Consequently, they may not devote as much time to fixing it in spatial and episodic memory. The writing and recopying done by hand may serve a rehearsal function--helping writers to "know" their own texts better.

In sum, with difficult or lengthy texts writers often had difficulty assessing their writing on-line and so used hard copy printouts to help them "get a sense of the text." Generally, writers were vague--and somewhat puzzled--about the problem. It clearly was not a problem they had expected or for which they had an explanation. The presence of this problem is intriguing however, for it suggests that a writer's reading of his or her own text, the representation of that text, and the assessment of its value are complex activities, involving not only conscious attention to intention and audience, but also a representation of the text as a spatial and a physical object.

What do these reading problems mean for students who use computers for writing and for those of us who teach computer writing courses? First, most of the writers I interviewed were very self-aware. Most of them evidenced a keen sense of their own writing processes, their strengths and weaknesses as writers, and how using a computer helped or hindered them during various writing tasks. They also had a metacognitive awareness of the problems that the computer caused them, and they had strategies for dealing with these problems--particularly they seemed to know when and how to use paper to supplement their computer writing. These writers were able to combine their knowledge of their own reading and writing processes with their knowledge of the computer and draw upon the strengths of both pen and paper and the machine.

However, it may not be realistic to expect students to bring this level of self-awareness to bear on computer writing tasks. Based on research in metacognition (Brown, 1978; Flavell, 1979; Scardamalia & Bereiter, 1985), we might expect that student writers 1) would not recognize that the computer has writing drawbacks, and that it might affect their reading of their own texts, and 2) would not use hard copy to supplement their computer writing the way

experts do. Problems reading on-line, then, may pose significant hurdles for students learning to write with word processors--difficulties that should be studied carefully as the use of computers in education becomes more widespread.

An Observational Study of Computer Writers' Reading Problems

The reading problems that computer writers report may have important implications for how--and how well-- they write. The reading and evaluating one's own text is an integral part of the writing process (Hayes & Flower, 1980). Writers read their own texts to detect errors, to judge coherence and organization, and to determine if the text meets their intentions (Hayes, Flower, Shriver, Stratman, & Carey, 1986).

In order to more systematically examine the reading problems of writers who use word processing, we designed a study to detail the occurrence and frequency of the four kinds of reading problems described above and patterns of similarity and difference between experienced and student writers.

The study employed naturalistic methods and a case study approach. For one semester (4 months) we tracked eleven case studies: six freshmen enrolled in writing with computers classes and five more experienced writers--people who had had several years computer experience and for whom writing constituted a major part of their work activities.

All writers used the same computer and word processing program for writing--the Andrew system, and the text editor EditText, currently under development at Carnegie Mellon University (Morris, Saytanarayanan, Conner, Howard, Rosenthal, & Smith, 1986).

The EditText program had been shown in a number of previous studies to be superior to more conventional personal computers in both reading and writing tasks. In a series of writing-related reading tasks reported in Haas and Hayes (1986), we found that readers were faster at retrieving information from a previously read text when they were using the Andrew workstation than when they were using a CRT-display on a terminal connected to a mainframe computer. We also found that subjects were faster at reordering a scrambled text when it was displayed in a large (9 inches by 10 inches) EditText window. Further, subjects in a writing experiment produced significantly longer texts when using Andrew and EditText than when using a personal computer and the text-editor Mince (Haas & Hayes, 1986b).

The decision to use the Andrew system for this study was influenced by two factors. First, using a system which seems to help writers more than conventional computers puts technology in its "best light." It would not be surprising--given the results of a number of studies of computer reading and writing (Gould, 1987; Gould, 1981; Haas, 1987; Haas & Hayes, 1986)--if a conventional computer (e.g., the IBM-PC) constrained writers as they read their own texts. Using a system which had already shown itself to be inferior for some reading and writing tasks would not be a fair test of how writers are affected by technology. Second, trends in the development of technology suggest that advanced systems such as Andrew may quickly become less expensive and more widely available and suggest that studies should be conducted with newer computer systems and word processing programs.

During the semester, the subjects were interviewed periodically about their writing with word processing; they were observed while writing in their natural environments--offices, classrooms, or terminal rooms; and they kept process

logs of the writing they were doing on-line. In the logs they were asked to note particularly when they used hard copy and what they used it for. The students kept logs of all their writing; the more experienced writers--since many of them spent most of every day writing--contracted to keep logs for some part of their writing.

The data collected (over 600 pages, about 50 pages per subject) were very rich, and included transcribed interviews; writing process logs; copies of all texts, notes and drafts produced; and field notes collected by the experimenter during observation sessions. Figures 1a and 1b show excerpts from writing logs and from transcribed interviews; the two subjects featured in the excerpts provide contrasting examples.

Use of Hard Copy for Reading Their Own Texts:

Sample Writer One

Diane: teacher, PhD candidate, software developer, and writer

Comments from log about why writer was using hard copy:

need to see what I've said--and in what order

to read and make changes on paper--also mark places that need more work

I need sense of whole text--print with duplex so I can see pages side by side

to read to see if some parts are redundant or out of place

Excerpts from interviews:

CH: What does the hard copy do for you?

Diane: It's sort of corny, but the first thing that came to my mind was, it makes it seem like a paper...all these little blinky lights and stuff...I trust this machine, but... it doesn't really seem like a paper until I have it on the paper, you know?

CH: What do you mean?

Diane: It makes it more real? I don't know. Substantial, concrete? I don't know why but I do still get hard copy and I always read the hard copy and I've learned to--this is funny--I now read my prose the way I read a book. And now I will go through my papers and mark them just like I mark the book, the main points, and in the margins I write where I have questions. I'll look for the best sequence, I'll mark in the margins where I've been vague...I can't get that distance here [on the screen].

Figure 1a

Use of Hard Copy for Reading Their Own Texts:

Sample Writer Two

Matt: freshman, 3-years experience with computers, A-student in high school English

Comments from log about why writer was using hard copy:

to see how long it is

to turn in

Excerpts from interviews:

CH: Why did you print it?

Matt: To turn in.

CH: Was that the only reason, did you need a hard copy for some reason?

Matt: No, that was the reason--she just wanted a hard copy to look at.

*****

Matt: So I pretty much left it like that [like I typed it in].

CH: Did you make any kinds of revisions?

Matt: Not really.

CH: Or print it out?

Matt: Not really.

CH: Or--

Matt: That was just it.

CH: And then you made a printout for your teacher?

Matt: Actually, this one I mailed. We sent our papers through the mail.

Figure 1b

While Writer One, Diane, noted several reasons for using hard copy in her log--among them checking order, marking the text, and critical reading--the comments in the log of Writer Two, Matt, indicate that he was using hard copy for fewer reasons--to check the length of the text and to turn in to his instructor. In the interviews, Matt was questioned about any other reasons for using hard copy, but he said there were none. In fact, in a part of the interview which unfortunately was not able to be transcribed, Matt said he thought it was "neat" that he could write, as he said, a "quote--paper" without "ever putting it on paper."

Diane, on the other hand, seems to like using paper when she writes on-line. The hard copy seems to give her some distance from her text, and allows her to read it critically. While Matt likes to write a "paper" without ever seeing it on paper, Diane doesn't seem to think her text is a "paper" until she sees it on paper. This study may well suggest factors that might contribute to Matt and Diane's different behaviors; however, as a observational study it is meant to postulate hypotheses rather than test them.

We found that Diane, Matt, and the other nine writers we studied used hard copy for reading, and they used the hard copy for the four distinct reading purposes outlined in the section above:

--Checking formatting

--Proofreading

--Reading to reorganize

--Critical reading, or "getting a sense of the text"

Figure 2 illustrates this coding scheme with examples from interviews and process logs.

Reading One's Writing On-Line:

Four Problem Areas

Formatting

I want to check it for double-spacing

I want to see if the tables line up.

I get a printout every little while to see if it's long enough yet.

Proofreading

I read for misspellings much better on paper.

The glare bothers me if I'm trying to read closely, say to proofread.

Reorganizing

I need the hard copy to see if things are really out of order.

I read to check the logical sequence of the ideas. You know, sometimes you just have to get your pen and spread the thing [the text] out all over the floor.

I try putting parts together--you know, holding up sections next to each other and reading them--to see if I really want to go through a big revision, a big reorganization.

Critical Reading, or the "text sense" problem

I need to really see what I've said--I need to get a sense of the whole text.

I tend to forget the part of the text I'm not seeing--what came before or what comes after--even though I can scroll to it.

I just get a printout and read it from paper every so often--to see that I'm still on track and that things are developing right.

Figure 2

It is important to recall that these writers were using the "Andrew" system--Andrew has a large screen, bit-mapped, black-on-white display, the kind of display that has been shown to be somewhat superior to more conventional CRT displays for some reading tasks (Gould & Grischowsky, 1984; Haas & Hayes, 1986). We might expect that reading problems of writers using more conventional systems would have even greater reading and evaluation problems.

The instances of hard copy reading were coded according to how the hard copy was being used; that is, each instance of hard copy reading was sorted into one of the four purposes shown in Figure 2. Reliability check revealed close to 90% agreement with a trained rater. Every instance of hard copy reading fit into our broad coding scheme, although not all instances of hard copy generation were used for reading. Sometimes writers generated hard copy only to hand in to their teachers, or to file without reading.

Although the number of instances of hard copy use for the two groups were similar (a total of 75 for the students and 80 for the more experienced writers) there were some interesting contrasts between the two groups in how hard copy was used. Of a total of 75 instances of hard copy use for reading, 75% of the students' use was for checking formatting, 13% was for proofreading, 8% was for reading to reorganize, and 4% was for critical text-sense reading. The hard copy reading of the more experienced writers showed a different pattern. Of the 80 instances of hard copy reading by more experienced writers, only 31% of the instances were for checking formatting; 9% were for proofreading, 21% for reading to reorganize, and 39% for reading for a sense of text. (See Table 1.)

Figure 3 presents the data in another way, and shows both the high incidence of format checking by student writers and the fact that the hard copy reading of the more experienced writers was more evenly distributed across the four uses.

	Students	More Experienced Writers
Formatting	75 %	31 %
Proofreading	13 %	9 %
Reorganization	8 %	21 %
"Text Sense"	4 %	39 %
	T = 75	T = 80

Table 1. Proportion of Hard Copy Use for Reading

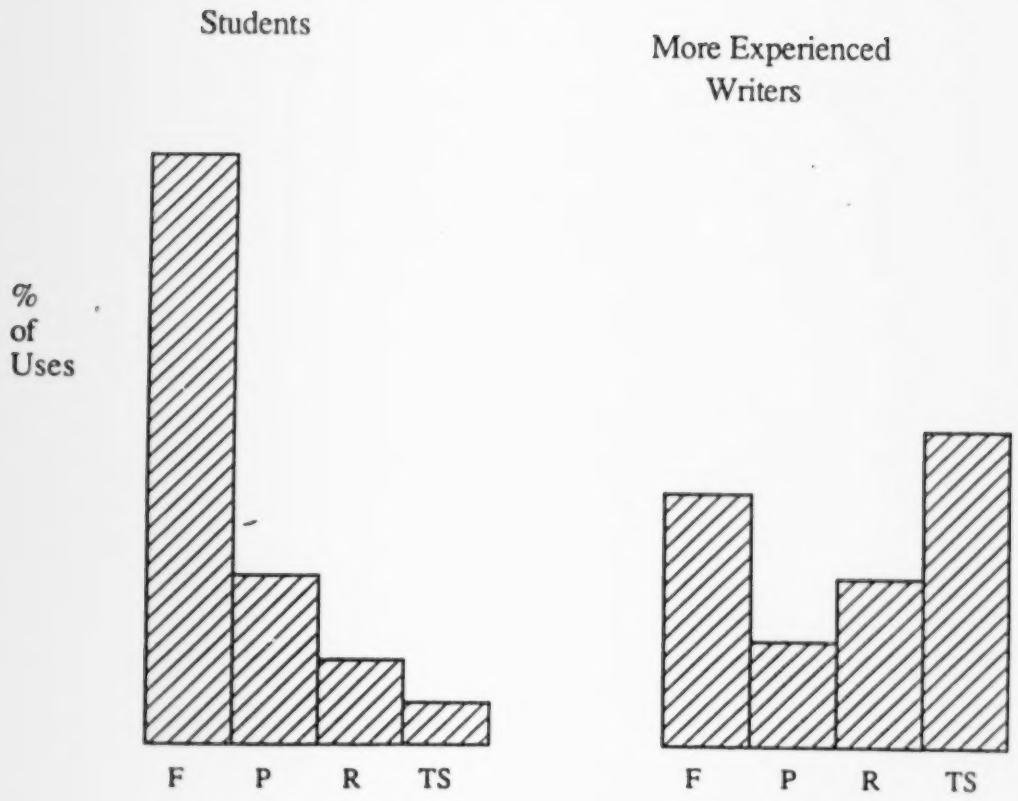

Figure 3. Differences Between Students and More Experienced Writers in use of Hard Copy for Reading

Since we were interested in differences between groups, particularly the large of amount of reading to check formatting by the student writers, we ran a simple t-test comparison to determine if the differences in how the two groups of writers used hard copy were significant. For each writer, we calculated the difference between hard copy use for checking formatting and for the other three purposes--proofreading, reading to reorganize, and critical reading. The resulting scores for student writers tended to be positive, while those for the experienced writers--who did less format checking and more of the higher level operations--were negative. The means for the two groups were 6.17 for students and -6.40 for experienced writers. As shown in Table 2, the groups differed significantly [$F (1, 9) = 12.92$, $p < .01$] in how they used hard copy.

Table 2.
Analysis of Variance:
Differences Between Experienced Writers and Students in How Hard Copy was Used.

Source	Sum of Squares	df	Mean Square	F	p
Mean	000.148	1	000.148	00.00	NS
Groups	430.693	1	430.693	12.92	.006
	300.003	9	033.337		

One possible conclusion from this comparison might be that students do not do the kind of reading required for reorganization or whole-text revision, and that they do not read their texts critically or worry much about a "sense" of the whole text.

However--while that may in fact be the case--another explanation is possible.

From the interviews, writing process logs, and observation session notes, we noticed that **how** the more experienced writers used hard copy seemed to be dependent on the **kind of task** they were doing. So we reanalyzed the data for the five experienced writers; we went back to the logs and interviews and pulled out those instances of reading problems which were clearly tied to specific kinds of tasks, as reported by the writers. We had no data about task variables to analyze for the student writers, because, interestingly, students made almost no comments--either in logs or in interviews--about task variables. It could be that students are unaware of task variables like length and difficulty, but this seems unlikely. Rather, we suspect the school writing tasks that were observed in this study were all very similar in length and in difficulty and so students just did not mention these variables.

Two kinds of task variables were examined: task length and task "familiarity;' that is, whether the writing task was well-rehearsed or "knowledge forming" (cf. Bereiter & Scardamalia's knowledge telling and knowledge transforming tasks, 1982). We did not analyze the texts themselves for either quality. Rather, we took the writers' word for it; that is, if a writer said a task was long or short, familiar or new, then that is how it was coded in this analysis. While this means that a text of 1000 word written by one writer could be coded as short, while one of a similar length by another writer could conceivable be coded as long, we believed that the writers' perceptions of tasks length and familiarity were more important for this analysis than any predetermined categories of length or familiarity.

There were 40 instances which we were able to code along the task length dimension; almost twice as many instances were associated with long tasks. Figure 4 shows how hard copy was used for tasks that writers called long and

short. While the short tasks seemed to elicit hard copy use mainly for checking formatting and proofreading, writers used hard copy for all four purposes when they were writing long tasks.

The two categories in the familiarity dimension were "rehearsed" and "knowledge-forming." Of the 27 instances of hard copy use that were associated with "rehearsed" and "knowledge-forming," fully twice as many were tied to the more difficult "knowledge-forming" writing. Figure 5 shows the patterns of hard copy use for "rehearsed" and "knowledge-forming" tasks. The rehearsed tasks elicited hard copy use only for formatting and proofreading, while the knowledge-forming tasks employed hard copy for all four purposes. Using hard copy to read for text sense seems especially important for long and/or knowledge-forming tasks.

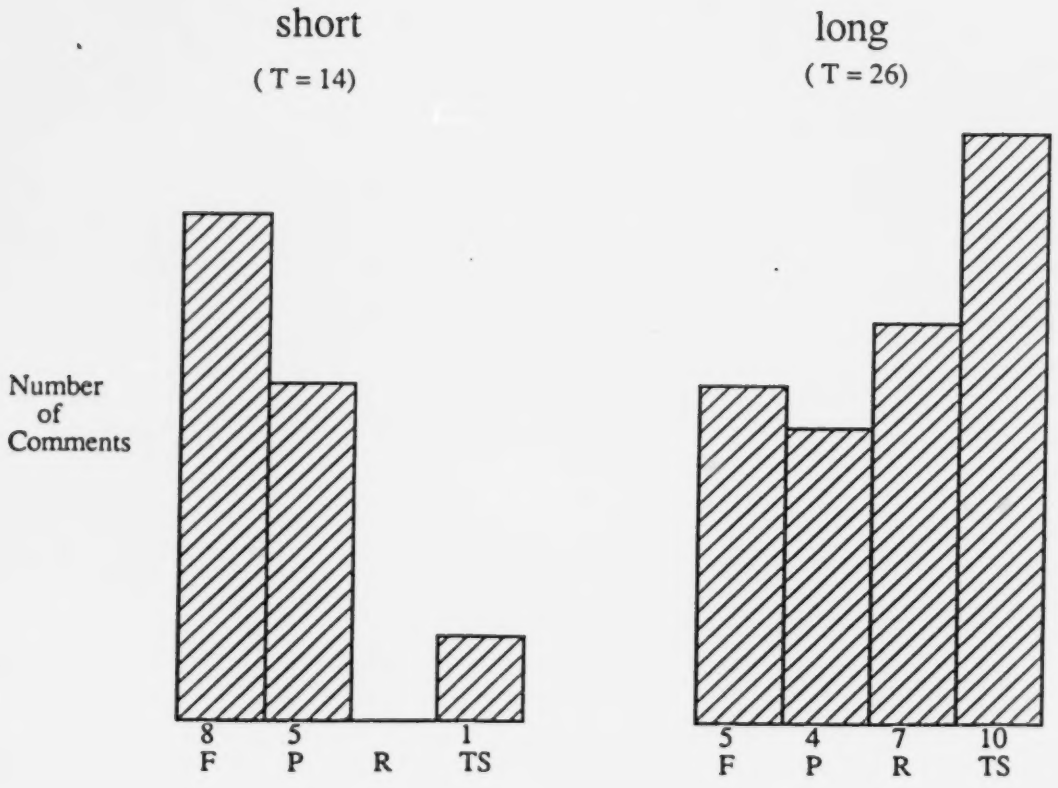

Figure 4. Use of Hard Copy for Reading: Differences Between Short and Long Tasks
(more experienced writers only)

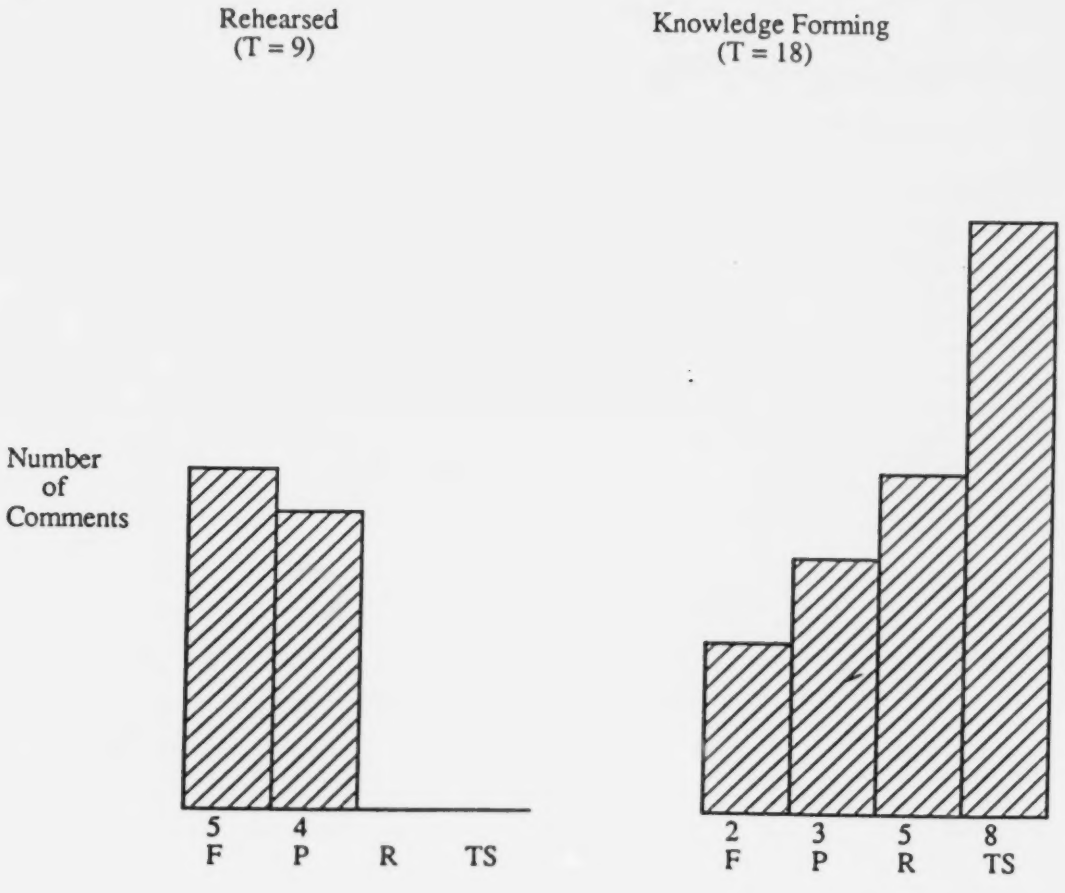

Figure 5. Use of Hard Copy for Reading: Differences Between Rehearsed and Knowledge Forming Tasks (more experienced writers only)

By comparing Figure 3 to Figures 4 and 5, we can see that the shape of the graph representing the short tasks and the one representing the rehearsed tasks resemble the graph for student writers. Some writing tasks may elicit more hard copy use, and the patterns of hard copy use may be different for long and short tasks, and for rehearsed and knowledge-forming tasks. Further, the students in this study may have been doing short, well-rehearsed writing tasks; the more experienced writers may have been doing very different tasks.

Conclusions

The interviews with computer writers and the observational study lead us to several tentative conclusions:

1. People have difficulties reading their own writing on-line and they often supplement word processing with hard copy printouts for reading.

2. Uses of hard copy for reading can include: checking formatting, proofreading, reading to reorganize, and reading to get a "sense of the text."

3. While there are differences in how student writers and more experienced writers use hard copy for reading, task variables such as length and difficulty may be important too.

Reading, reviewing, evaluating are important in writing. If evaluative reading is problematic on-line--and if these problems are tied to particular kinds of writing tasks--a logical inference would be that the word processor accommodates or invites some writing tasks more than it does others.

One of the writers expressed the idea this way:

> [Creating] class assignments and stuff like that are pretty second nature to me--I can write those in my sleep, and so I'm usually pretty confident that if I've spelled the word correctly and it reads like English, then it's fine. But when I'm in a more creative mood, like when I'm trying to argue for something or express new ideas or things that I'm working on my self, I'm less secure in that, less secure in just having it on the screen.
>
> You know, it may be that writing is learning things. It may be that in those other assignments [harder ones], as you write then you're developing--I'm developing the argument or I'm developing the information that I want to give and so, it demands that I look at it again, on paper, and say OK, this is really OK. I wouldn't want to think how many hard copies or how many times I've done the same section--in my dissertation. And then you say, forget the whole thing and start all over. Whereas some of the other things [shorter,easier] I think, you know, the nature of the task is such that you can look at it on-line right away and say, "That's fine, that's it."

What this writer seems to be saying is that some tasks--short, well-rehearsed--are easy to write and evaluate on-line. Other tasks--longer, more complex ones-are difficult to evaluate on-line and require hard copy to supplement word processing.

Certainly verification and converging evidence are necessary, but if this is the case--if some kinds of writing are better suited to the word processor, and if using word processing can compound some kinds of student writing problems--what are the educational implications?

We *could* --maybe we should--design assignments for computer writing classes that are short, and well-rehearsed in order to help students avoid on-line evaluation problems. This may not be what we want to do, given our educational objectives. A more long term solution would be to determine, though further research, what kinds of computer variables lead to reading difficulties and work with software developers and system designers to alleviate the problems. Right now, however, we can make explicit to our students the dangers of relying completely on the word processor and point out to them the

ways in which they might use hard copy to supplement their computer writing, especially to read their own developing texts.

We may sometimes forget that behavior that to us is second nature may need to be made explicit to our students. Matt's teacher--Diane--is very savvy and very self-aware about using hard copy to supplement her computer writing. It wouldn't occur to her to "do without" hard copy. For Diane, using a word processor does not mean foregoing pen and paper. But it doesn't occur to Matt that he need to use paper at all--in fact he prides himself on doing without it. Given the fairly conclusive research on difficulties reading on-line, it seems that Matt may be making a mistake. Somehow either Diane had not given the message--or Matt had not gotten it--that writing with a word processor may not mean foregoing pen and paper. When we teach, encourage, or even require our students to use a word processor for writing, we should make explicit for them when and how the machine can help them. We also need to make explicit information about when relying on conventional technology is the smarter move to make.

Far from being the idiosyncratic musings of computer skeptics, the reports of these computer writers suggest that there are important limitations to using computers for writing, and that reliance on pen and paper can help circumvent those limitations. Further, the computer writing problems outlined here are not ones we could easily predict from our current theories of writing: while we believe that reading and writing are closely tied, the role of reading in the process of writing has not been fully articulated or explored. The advent of the computer in classrooms and offices of writers offers us a unique opportunity--and need---to explore more carefully how writers read their own texts, how they represent their texts to themselves, and how various physical, temporal, and

spatial factors may influence how they "see" their texts.

References

Bereiter, C. & Scardamalia, M. (1982). From conversation to composition: The role of instruction in a developmental process. In R. Glaser (Ed.), *Advances in Instructional Psychology* (Vol. 2). Hillsdale, N. J: Lawrence Erlbaum Associates.

Bridwell, L., Sirc, G., & Brook, R. (1985). Revising and computing: Case studies of student writers. In S. Freedman (Ed.), *The Acquisition of Written Langauge: Revision and Response.* Norwood, NJ: Ablex.

Brown, A. L. (1978). Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in Instructional Psychology.* Hillsdale, N. J.: Lawrence Erlbaum.

Flavell, J. H. (1979). Metacognition and cognitive monitoring. *American Psychologist,* 34, 906-911.

Gould, J. D., Alfaro, L., Finn, R., Haupt, B., Minuto, A., & Salaum, J. (1987, April) Why reading was slower from CRT displays than from paper. In *Proceedings of CHI+GI 1987.* ACM, New York, 7-12.

Gould J. D. & Grischkowsky, N. (1984). Doing the same work with hard copy and with cathode-ray tube computer terminals. *Human Factors, 26*(3), 323-337.

Haas, C. & Hayes, J. R. (1986). What did I just say? Reading problems in writing with the machine. *Research in the Teaching of English, 20*(1), 22-35.

Hansen, W. J., Doring, R., & Whitlock, I. R. (1978). Why an examination was slower on-line than on paper. *International Journal of Man-Machine Studies, 10,* 507-519.

Harris, J. (1985). Student writers and word processing: A preliminary evalaution. *College Composition and Communication, 36,* 323-330.

Hayes, J. R., Flower, L., Schriver, K., Stratman, J., & Carey, L. (1987). Cognitive processes in revision. In S. Rosenberg (Ed.), *Advances in Applied Psycholinguistics, Volume II: Reading, Writing, and Language Processing.* Cambridge, England: Cambridge University Press.

Heppner, F. H., Anderson, J. C. T., Farstrup, A. E., & Weiderman, N. H. (1985). Reading performance on a standardized test is better from print than from computer display. *Journal of Reading,* January, 321-325.

Holley, C. D. & Dansereau, D. F. (1984). *Spatial Learning Strategies: Techniques, Applications, and Related Issues.* New York: Academic Press.

Kotovsky, K., Hayes, J. R., & Simon, H. A. (1985). Why are some problems hard? Evidence from Tower of Hanoi. *Cognitive Psychology 17,* 248-294.

Morris, J., Satyarayanan, M., Conner, M., Howard, J. H., Rosenthal, D., & Smith, F. D. (1986). Andrew: A distributed personal computing environment. Communications of the ACM, 29 (3), 184-201.

Rothkopf, E. Z. (1971). Incidental memory for location of information in text. *Journal of Verbal Learning and Verbal Behavior, 10*, 608-613.

Scardamalia, M. & Bereiter, C. (1985). Fostering the development of self-regulation in children's knowledge processing. In S. Chipman, J. Segal, & R. Glaser (Eds.), *Learning and Thinking Skills: Research and Open Questions*. Hillsdale, N. J: Lawrence Erlbaum Associates.

Stallman, R. M. (1981). EMACS: The extensible, customizable, self-documenting display editor. *SIGPLAN NOTICES, 16* (6), 147-156.

Witte, S. P. (1985). Revising, composing theory, and research design. In S. Freedman (Ed.), *The Acquisition of Written Langauge: Revision and Response*. Norwood, NJ: Ablex.

Wright, P. & Lickorish, A. (1983). Proof-reading texts on screen and paper. *Behavior and Information Technology 2*(3), 227-235.